

## **NUTRIENT SUPPLEMENTATION**

The following text is a general draft protocol developed by the Washington Department of Fish and Wildlife. As this protocol was developed and published separately from the Stream Habitat Restoration Guidelines, it appears here in the same format in which it was originally published and has not been altered to fit the format of the current document. This draft protocol is subject to change. The most current version of the protocol is available on the internet at \_\_\_\_\_.

# **PROTOCOLS AND GUIDELINES FOR DISTRIBUTING SALMONID CARCASSES, SALMON CARCASS ANALOGS, AND DELAYED RELEASE FERTILIZERS TO ENHANCE STREAM PRODUCTIVITY IN WASHINGTON STATE**

The declining abundance in many wild salmonid populations in Washington can be attributed to a combination of factors including harvest and hatchery issues, hydroelectric operations, habitat degradation and loss, stream flow, altered basin hydrology, and reduced stream productivity. Restoration of salmon populations to levels capable of sustaining consumptive fisheries will require addressing all these issues; nutrient restoration addresses only a part of the overall problem.

There are currently four options being considered to increase the level of nutrients in freshwater ecosystems in order to restore ecosystem productivity to “historic levels”. These are the application of fertilizers, the application of carcass analogs (processed fish cakes), the distribution of salmonid carcasses from fish hatcheries, and the allowance of increased levels of natural spawning by anadromous fish. These protocols and guidelines deal with nutrient recovery utilizing the first three methods, provision for increased spawner escapements will be dealt with in other forums.

The application of fertilizer to increase wild fish production has been conducted in the Pacific Northwest for years. Currently, there are two methodologies in use. One involves the introduction of liquid fertilizer into the water, either through large slug dosages or through low level drip. The second involves the placement of solid fertilizer pellets that dissolve at a predetermined rate, releasing nutrients over a period of months. Both methods have been shown to cause substantial increases in fish growth, survival, condition factors, and the like. Water quality monitoring associated with the application of these fertilizers has shown that they are rapidly taken up into the food chain and are generally not detectable in the water column outside of the treatment area/reach.

The use of carcass analogs is an emerging technology. The concept is that fish carcasses and other fish processing waste material is converted into a solid cake. The cake would be treated to kill associated fish pathogens. The advantage of the analog is that they are lighter in weight per unit of nutrient (when compared to carcasses) and they would present a much lower risk of pathogen transfer. The technology is currently in development and testing.

The predominant method currently used to increase nutrients in freshwater and terrestrial ecosystems has been through the distribution of carcasses of salmonids that have returned to hatcheries.

In order to determine whether or not a system is in a state of nutrient deprivation/starvation, the natural spawning escapement levels discussed in Bilby et al. (2001) will serve as minimums. Escapements below these levels will be assumed not to meet the minimal nutrient needs of the ecosystem. Other direct measures, such as smolts becoming older and/or smaller, analysis of benthic sediments, analysis of sequestration of marine derived nutrients in trees, etc. will also meet the assumption of lack of nutrients.

## **GOAL OF NUTRIENT RESTORATION ACTIVITIES:**

Increase the biological productivity of Washington’s streams, riparian areas, upland areas, and estuaries by returning the nutrients originally supplied by anadromous fish carcasses back to the anadromous zone of spawning streams. Ultimately, the goal is the functional restoration of the ecosystems supported by naturally spawning salmonids. Restoration of this functionality will require the restoration of the terrestrial and aquatic communities in addition to simple anadromous fish restoration. It will also require the restoration of hydrologic cycles, restoration of the relationship between rainfall and streamflow, and restoration of aquatic habitat.

## **OBJECTIVE # 1:**

Enrich the nutrient supply to aquatic ecosystems (primary producers, scavengers, browsers, predators), enabling their population increases to be used for the trophic benefit of all interdependent species. This will result in increases in individual size and survival of juvenile salmonids living in the streams.

## **OBJECTIVE # 2:**

Increase productivity in riparian zones and associated upland areas that will benefit the animals and plants which depend upon them.

## **OBJECTIVE # 3**

Provide analogs or carcasses for direct consumption by juvenile fishes and aquatic macroinvertebrates.

## **OBJECTIVE # 4**

Provide alternatives to the use of anadromous salmonid carcasses where a supply of carcasses is not available.

## **OBJECTIVE # 5**

Where appropriate, conduct water quality monitoring to document the uptake of nutrients while maintaining water quality for non fish-producing purposes. This monitoring should be structured to demonstrate not only the cultural oligotrophication of watersheds but demonstrate the uptake of the nutrients and the ecosystem benefits therefrom. Monitoring will be structured, where possible, to result in peer reviewed publication in the appropriate scientific journals.

## **PREMISES:**

\*\* Actions taken to restore a stream's productivity through restoration of nutrients shall not be viewed as supplanting or supplementing natural spawning by wild salmonids. The ultimate goal is to provide the nutrients necessary to drive the ecosystem only through natural spawning by anadromous salmonids.

\*\* Streams identified for nutrient enhancement with carcasses must be within a designated Fish Health Management Zone (FHMZ), or smaller, that contains the source hatchery facilities.

\*\* No nutrients will be distributed in stream reaches formally identified as being impaired because of excess nutrients without the express approval of the Department of Ecology. The Department of Ecology will provide WDFW with a current list of impaired waterbody segments and, if appropriate the specific timing (within the year) of that impairment.

\*\* All projects which exceed the identified biomass densities or those that introduce fertilizer will be monitored as follows: One sample immediately upstream of the uppermost input point, one sample at the downstream end of the calculated treatment zone and one sample half a kilometre downstream from the lower end of the "treatment zone". Samples will be collected monthly during the period of fertilizer introduction and will continue for two months after the calculated date of pellet disintegration or after last application of liquid fertilizer. Measurements will be for parameters identified in the Memorandum of Agreement (MOA) supporting the NPDES discharge permit.

\*\* All projects will be covered by formal approval of the Department of Fish and Wildlife and Department of Ecology through individual project MOAs. The MOA will accompany transport and depositing of materials.

## **CRITERIA FOR TREATMENT STREAM IDENTIFICATION:**

- 1) Treatment reaches shall be within the current anadromous zone of a watershed or within areas historically accessible to anadromous fish; exceptions will be based on research study needs.
- 2) Streams that have historic data sets and/or ongoing assessment projects that can be complemented by nutrient restoration will be given high priority in project planning. Streams with ongoing ecosystem assessment studies that would be adversely affected by nutrient enhancement will be avoided.
- 3) Streams or stream reaches where treatment ends less than two km upstream from municipal water supplies will be considered only with the expressed written concurrence of the water purveyor. Similarly, domestic water rights recognized by DOE will receive the same consideration.
- 4) Streams or stream reaches with identified water quality constraints for nutrients will be avoided; exceptions will be made only with written concurrence of the regulatory authority.
- 5) Treatment streams should have access points to the treatment reaches, (bridges, wet crossings, culvert crossings, etc.) to accommodate nutrient deposition, distribution, and monitoring.
- 6) Spawner index streams and smolt evaluation streams will not be selected for nutrient restoration unless potential impacts are resolved with the research or evaluation agency or organization.

## **CRITERIA FOR ADULT CARCASS DEPOSITION:**

- 1) Temporal and spatial distribution should reflect historic anadromous spawn-timing and abundance for a particular stream, for each species. For purposes of this program, all carcasses are considered equal from a nutrient per weight basis. Consequently, the actual distribution goal may be calculated as biomass and then converted to fish numbers. In practice, chinook carcasses may be used as a substitute for coho, and vice versa, depending upon availability. Further, testing for pathogens, availability of access due to snow, etc. shall be considered when setting up distribution schedules.
- 2.) The maximum number of carcasses distributed within a stream segment will be based on Bilby et al. (2001). For coho, the target level is 0.15 kg/square metre of stream surface area based on bankfull channel width. Summer low flow area can be substituted as a conservative density. For mass spawning species of salmon (pink, sockeye, chum), 0.78 kg/square metre will be used. For chinook, which is a mass spawning species but also uses the freshwater environment for rearing up to a year, a value of 0.39 kg per/square metre will be used. No values have been developed for steelhead; because of similarity in life history patterns the coho value of 0.15 kg/square metre of stream surface area will be used. In streams where estimates of the natural spawning escapement are routinely made, carcass numbers can be reduced by the recent 5-year moving average for natural escapement to the treatment reach. For determining total carcass deposition maximums, the area historically available to each species will be used to calculate the loading rates. This results in a separate calculation for each species/timing segment. Spawn timing will need to be factored into distribution schedules.
- 3) Carcasses will be used within designated watersheds or FHMZ as identified by WDFW Fish Health Specialists.
- 4) Carcasses will be used from stocks that have been screened for pathogens as prescribed in the Co-managers Disease Control Policy.
- 5) If necessary to avoid duplicate counting or interference with spawner enumeration or other studies, carcasses used for nutrient enhancement will receive a distinctive external mark or tag. As noted in (1), species may be substituted in order to avoid the potential for enumerating a distributed carcass as natural escapement.
- 6) If necessary to avoid confusion with specific genetic sampling studies, carcasses will have an identifiable external mark or non-target species will be utilized.
- 7) All use of carcasses for nutrient restoration will follow the specific plan submitted by the applicant and approved in the formal project review process.
- 8) A copy of the final project approval will accompany transport and deposition of carcasses.

- 9) Artificial deposition of carcasses should be avoided at flow levels (e.g. high flows/freshets) that would compromise the carcass placement objectives.
- 10) Artificial deposition of salmonid carcasses must not create a direct human health hazard.
- 11) Frozen carcasses can be used to approximate historic run (mortality) timing and to improve distribution to inaccessible stream reaches.
- 12) Distribution of carcasses should include shoreline and shallow water reaches of the stream.
- 13) Final Project approval or denial will occur at the WDFW Regional Fish Program Manager level after appropriate internal review. The Regional Fish Program manager will ensure that Co-managers, the Department of Ecology, and other affected fish management entities have been consulted during project approval. Distribution of final approval/disapproval will be by the WDFW Hatcheries Division.

## **CRITERIA FOR CARCASS ANALOG DEPOSITION:**

- 1) Temporal and spatial distribution should reflect historic anadromous spawn-timing and abundance for a particular stream, for all species. For purposes of this program, the amount of analogs to be distributed will be converted to carcass biomass by correcting for the moisture/nutrient content of the analog. The actual distribution goal will be calculated as biomass and then converted to analogs.
- 2.) The maximum number of analogs distributed within a stream segment will be based on Bilby et al. (2001). For coho, the target level is 0.15 kg/square metre of stream surface area. This value was determined based on bankfull channel width. Summer low flow area can be substituted as a conservative density. For mass spawning species of salmon (pink, sockeye, chum), 0.78 kg/square metre will be used. For chinook, which is a mass spawning species but also uses the freshwater environment for rearing up to a year, a value of 0.39 kg per/square metre will be used. No values have been developed for steelhead; because of similarity in life history patterns the coho value of 0.15 kg/square metre of stream surface area will be used. In streams where estimates of the natural spawning escapement are made, analog biomass can be reduced by the recent 5-year moving average for natural escapement to the treatment reach. For determining analog deposition maximums, the area historically available to each species will be used to calculate the loading rates. This results in a separate calculation for each species. Spawn timing will need to be factored into distribution schedules.
- 3) Analog will be processed so that fish pathogens present in the raw material are destroyed during processing.
- 4) Use of analogs for nutrient restoration will follow the specific plan submitted by the applicant and approved in the formal project review process.
- 5) A copy of the final project approval will accompany transport and deposition of analogs.
- 6) Deposition of analogs should be avoided at flow levels (e.g. high flows/freshets) that would compromise the analog placement objectives.
- 7) Deposition of analogs must not create a direct human health hazard.
- 8) Final Project approval or denial will occur at the WDFW Regional Fish Program Manager level after appropriate internal review. The Regional Fish Program Manager will ensure that Co-managers, the Department of Ecology, and other affected fish management entities have been consulted during project approval. Distribution of final approval/disapproval will be by the WDFW Hatcheries Division.

## **CRITERIA FOR FERTILIZER DEPOSITION:**

- 1) Temporal and spatial distribution should reflect historic anadromous spawn-timing for a particular stream, for all species. Since the application of fertilizer targets only the dissolved nutrient fraction contained in a salmonid carcass, if data show that the release of dissolved nutrients by decomposing carcasses occurs at a time different from the time of carcass deposition, then fertilizer application can duplicate the release timing. Further, applications to lakes can be timed to promote maximum uptake by the phytoplankton community.
- 2) The maximum amount of fertilizer to be deposited will be based on the recommendations of Ashley and Slaney (1997) which is to achieve an instantaneous Soluble Reactive Phosphorus level over the 120 day treatment of 3-5 micrograms per litre at average streamflow during application/release. Treatment reach will be defined based on the Ashley/Slaney calculations or other methodologies as information is developed.
- 3) Determination of the need to apply fertilizer will be based on recent year spawner biomass deposition with 0.15 kg/metre squared for coho and steelhead, 0.39 kg/metre squared for chinook, and 0.78 kg/metre squared for pink, chum, and sockeye serving as prima facie evidence of cultural oligotrophication. For lakes, sediment core studies showing historic phosphorus deposition and/or zooplankton communities will be used as justification for programs and for determining natural levels of nutrient input to the system.
- 4) The fertilizer formulation will be reviewed to ensure that the entire formulation, including inert and other constituents do not constitute a fish health, human health, or water quality problem.
- 5) Use of fertilizer for nutrient restoration will follow a specific plan agreed to among water quality and fish management agencies. This plan will serve as a pre-deposition template for evaluating and directing carcass distribution requests or applications.
- 6) Transport and deposition of fertilizers will be accompanied by the appropriate approvals.
- 7) Placement of fertilizer should avoid flow levels that would compromise the placement objectives.
- 8) Each fertilizer application project will include a water quality monitoring component. At the minimum, the proponents will be required to collect Soluble Reactive Phosphorus samples from a point 50 m upstream of the uppermost fertilizing site, the midpoint of the treatment reach, the calculated bottom of the treatment reach, and 500 m downstream of the bottom of the treatment reach. Samples will be collected monthly from one month before fertilizer deposition to two months after the calculated release of the last of the fertilizer. For example, if 120 day release formulation is used, samples would be collected on day number -30, 0, 30, 60, 90, 120, 150, and 180.
- 9) Final Project approval or denial will occur at the WDFW Regional Fish Program Manager level after appropriate internal review. The Regional Fish Program Manager will ensure that Co-managers, the Department of Ecology, and other affected fish management entities have been consulted during project approval. Distribution of final approval/disapproval will be by the WDFW Hatcheries Division.

#### **CRITERIA FOR TERRESTRIAL DEPOSITION OF CARCASSES**

Deposition of carcasses or analogs in terrestrial areas within twenty (20) m of flowing water will be treated as if they were placed in the stream and will comply with the conditions listed above with regard to Fish Health Management Zones. It is desirable that, under normal deposition plans, some of the carcasses or analogs be applied terrestrially or in shallow water.

#### **CRITERIA FOR ALL PROJECTS:**

- 1) Approval is continuous as long as all operational requirements of a specific project are met.
- 2) Proponent must annually report to WDFW per the MOA. Proponent will indicate plans for the next year's activities and any changes proposed. This will be reported to the WDFW Hatcheries Division Environmentalist and will serve as the application for renewal for the subsequent year's program. The report must be received by June 30 following deposition. WDFW will ensure that interested agencies receive data summaries and results of monitoring. WDFW will annually issue an MOA, based on receipt of the annual report, which will be supplementary to the original approval document and must

be present when carcasses, analogs, or fertilizers are transported and applied.

3) These criteria apply only to projects reviewed by the WDFW procedure. For carcass distribution projects, these protocols apply only WDFW operated facilities or to WDFW associated Coops. Carcasses from Federal or Tribal hatcheries can be covered by these protocols if the agency supplying the carcasses has met the necessary environmental review required by the appropriate governmental entity.

4) Applications will be reviewed and approved on a year-long basis. In order to have approval by September 1 it will be necessary to apply by July 1.

## **APPLICATION AND REVIEW PROCEDURE FOR ALL PROJECTS:**

1) Contact WDFW Volunteer Office for copies of the protocols and an application form. Specific technical assistance will be available from the Technical Assistance List accompanying the application package.

2) Completed application forms are forwarded to the WDFW Hatcheries Division Environmentalist who will initiate the review process. The address is:

WDFW Hatcheries Division Environmentalist  
600 Capitol Way N  
Olympia, WA 98501-1091

## **For applications for carcass distribution ONLY:**

*A) The completed application will be reviewed by the Aquaculture Coordinator who will approve/deny use of carcasses.*

*B) WDFW Fish Health Manager will forward a copy of the application to the Northwest Indian Fisheries Commission for Co-Manager review. Following review by the Fish Health Manager the application will be forwarded to the Hatcheries Operations Manager for the source facility. The application will then be returned to the Hatcheries Division Environmentalist.*

*C) Applications that are recommended as Denied will be returned to the applicant with explanation. If the Hatcheries Division recommends changes in the application prior to approval, the Division Environmentalist will contact the applicant to address the necessary modifications.*

3) All completed applications (fertilizer, analog) and Hatcheries Division approved (carcass) will be forwarded to the Regional Fish Program Manager for local review.

4.) Following regional review the Regional Fish Program Manager will approve or deny the application.

5.) The approved application and review forms will be returned to the Hatcheries Division Environmentalist for distribution. An MOA will be developed for each project based on the approved application and will be append to the WDFW approval.

## **LITERATURE CITED**

Ashley, K. I., and P. A. Slaney. 1997. Accelerating recovery of stream, river, and pond productivity by low-level nutrient replacement, Chapter 13 *In* Slaney and Zaldokas, eds. Fish habitat rehabilitation procedures. Watershed Restoration program, MOELP, Vancouver BC.

Bilby, R.E., B. R. Fransen, J. K. Walter, C. J. Cederholm, and W. J. Scarlett. 2001. Preliminary evaluation of the use of stable isotope ratios to establish escapement levels for Pacific salmon. *Fisheries* 26:6-14.



**Application to Conduct  
a Nutrient Restoration  
Project**

**Applicant**

---

**Address**

---

---

**Phone**

---

**Fax**

---

---

E-mail	<hr/>					
WDFW Region	1	2	3	4	5	6
Type of Project (circle)	Carcass Distribution		Analog Distribution		Fertilizer Distribution	

## Carcass Request

Source Hatchery:

<u>Species</u>	<u>Number</u>
Chinook	
Coho	
Chum	
Pink	
Sockeye	
Steelhead	
Cutthroat	

## Analog Request

Source

Amount

## Fertilizer Request

Type (circle)

Drip   Slug   Delayed Release

Amount to be deposited

Formulation and concentration

Location of Project 

---

Stream name, WRIA number, *if known*, and general location within stream (attach map). If more than one stream please number them on the list and on the map.

---

Distribution and Monitoring Plan:



Send to:  
WDFW Hatcheries Division Environmentalist  
600 Capitol Way N  
Olympia, WA 98501-1091

**STATE OF WASHINGTON**  
**DEPARTMENT OF FISH AND WILDLIFE**  
  
**Stream Nutrient Recovery Program**  
**Review and Approval**

Please review the attached project. Sign, attach any comments, and forward to the next person on the list. Please assist in the prompt processing of the proposal.

**Applicant:**

<b>Hatcheries Program</b>	Signature	Date
Fish Health Division Manager (includes NWIFC notification) :		

Aquaculture Coordinator:

Area Division Manager:

Program Environmentalist:

**REGIONAL REVIEW**

**Due Date:**

**Habitat Management Program**

Regional Habitat Program Manager:

**Wildlife Management Program**

Regional Wildlife Management Program Manager:

**Enforcement Program**

Enforcement Captain:

**Department of Ecology**

Regional Office:

**FINAL APPROVAL**

**Fish Management Program**

Regional Fish Program Manager:

*Post approval notification list:*

**HATCHERIES PROGRAM:**

Hatchery Complex Manager  
Area Fish Health Specialist  
Program Environmentalist  
Aquaculture Coordinator

**ENFORCEMENT PROGRAM:**

District/Area Enforcement Officer \_\_\_\_\_

**FISH MANAGEMENT PROGRAM:**

Area Fish Management Biologist \_\_\_\_\_  
Regional Fish Program Manager  
Volunteer Coordinator

**WILDLIFE MANAGEMENT PROGRAM:**

Area Wildlife Management Biologist

**HABITAT MANAGEMENT PROGRAM:**

Area Habitat Biologist

**DEPARTMENT OF ECOLOGY:**

Regional office

Revised 22 March 2002